

# Status of NHTSA's Ejection Mitigation Research Program

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May 13, 2003

# Ejection Mitigation Problem Definition

- 52,900 Ejections per Year
  - 1% of all crash-involved occupants
- 10,300 Ejected Fatalities per Year
  - 32% of all fatalities
  - 6,000 through side windows
- 10,600 Rollover Fatalities per Year
  - 3,800 ejected through side windows

# Ejection Mitigation Research Program Goals

- Demonstrate Countermeasure Feasibility
  - Evaluate ejection mitigation capability
  - Evaluate injury-causing potential
- Develop Occupant Retention Test
  - Full-scale rollover tests not repeatable
- Develop Rollover Sensor Test

# Ejection Mitigation Dynamic Rollover Fixture (DRF)

- Research Tool to Evaluate Countermeasures
- Produces Repeatable Full-Dummy Ejections
  - Allows dummy response measurements
- Produces Realistic Roll Rates
  - Up to 360 deg/sec
- Variable Occupant-to-Window Speeds
  - 15 to 30 kmph
- Variable Occupant Trajectories and Impact Locations
- Does Not Simulate Lateral Vehicle Accelerations



# Ejection Mitigation Countermeasure Candidates

- Inflatable Systems
  - Advanced Head Protection System (AHPS)
    - Simula Automotive Safety Devices
  - Prototype Window Curtain
    - TRW Automotive
- Advanced Side Glazings
  - Bi-laminate
  - Tri-laminate
  - Modified door frame
- Inflatable/Glazing Combination
  - Less door frame modifications



# Ejection Mitigation DRF Testing

- Window Treatments
  - Open window
  - Inflatables, glazings, combination
- Dummy Sizes
  - 50<sup>th</sup> male
  - 5<sup>th</sup> female
  - 6 year-old
- Seated Positions
  - Behind steering wheel
  - Inboard

Note: The data in this table are revised from those presented in paper #342 of the 18<sup>th</sup> ESV Conference

		Dummy Position	Test Number	HIC <sub>36</sub>	Axial Compression N (% IARV)	Axial Tension N (% IARV)	Lateral Shear N	Lateral Bending N-m	
Open Window	50 <sup>th</sup> Male	Behind Wheel	DRF_20	43	447 (11%)	862 (21%)	327	19	
			DRF_29	34	0 (0%)	723 (17%)	290	19	
			DRF_30	55	0 (0%)	972 (23%)	296	16	
		Inboard	DRF_21	No Dummy Response Data					
	5 <sup>th</sup> Female	Behind Wheel	DRF_38	25	32 (1%)	601 (23%)	221	14	
			DRF_43	41	51 (2%)	623 (24%)	268	15	
			DRF_44	69	0 (0%)	818 (31%)	329	19	
		Inboard	DRF_45	90	172 (7%)	871 (33%)	307	17	
TRW Air Curtain	50 <sup>th</sup> Male	Behind Wheel	DRF_17	8	325 (8%)	292 (7%)	638	42	
			DRF_32	22	181 (5%)	314 (8%)	643	43	
			DRF_33	10	282 (7%)	238 (6%)	716	35	
			DRF_67	50	1770 (44%)	909 (22%)	1020	53	
		Inboard	DRF_34	11	730 (18%)	918 (22%)	790	45	
			DRF_35	30	1176 (29%)	1123 (27%)	950	61	
	5 <sup>th</sup> Female	Behind Wheel	DRF_36	No Dummy Response Data					
			DRF_37	22	617 (24%)	375 (14%)	511	20	
		Inboard	DRF_46	15	697 (28%)	757 (29%)	754	35	
			DRF_47	13	614 (24%)	650 (25%)	729	36	
			DRF_51*	15	352 (14%)	345 (13%)	668	42	
	Simula AHPS	50 <sup>th</sup> Male	Behind Wheel	DRF_68	15	1247 (31%)	409 (10%)	450	26
DRF_69				16	1126 (28%)	427 (10%)	344	31	
Inboard			DRF_70	19	2203 (55%)	1075 (26%)	315	60	
			DRF_71	21	2369 (59%)	494 (12%)	388	52	
5 <sup>th</sup> Female		Behind Wheel	DRF_60	10	0 (0%)	283 (11%)	447	29	
			DRF_61	12	0 (0%)	290 (11%)	491	30	
		Inboard	DRF_62	15	0 (0%)	605 (23%)	586	33	
			DRF_63	20	0 (0%)	537 (20%)	572	35	
Advanced Glazing (Laminated Glazing)	50 <sup>th</sup> Male	Behind Wheel	DRF_72	84	2084 (52%)	364 (9%)	667	49	
		Inboard	Test Not Yet Conducted						
	5 <sup>th</sup> Female	Behind Wheel	DRF_64	57	895 (36%)	307 (12%)	200	19	
		Inboard	DRF_66	121	1230 (49%)	515 (20%)	345	26	
Combination: TRW Air Curtain/Laminated Glass	50 <sup>th</sup> Male	Behind Wheel	Test Not Yet Conducted						
		Inboard	Test Not Yet Conducted						
	5 <sup>th</sup> Female	Behind Wheel	DRF_80	34	310 (12%)	260 (10%)	338	13	
			DRF_82*	27	345 (14%)	147 (6%)	237	14	
		Inboard	DRF_81	10	731 (29%)	413 (16%)	442	29	
			DRF_83*	9	1220 (48%)	564 (22%)	630	13	
Combination: Simula AHPS/Laminated Glass	50 <sup>th</sup> Male	Behind Wheel	Test Not Yet Conducted						
		Inboard	Test Not Yet Conducted						
	5 <sup>th</sup> Female	Behind Wheel	DRF_84	13	351 (14%)	220 (8%)	317	24	
			DRF_86*	10	576 (23%)	265 (10%)	161	14	
		Inboard	DRF_85	21	2060 (82%)	525 (20%)	385	22	
		DRF_87*	10	743 (29%)	452 (17%)	223	24		

\* Dummy Positioned Closer to Steering Wheel with Foam Block Spacer

# Ejection Mitigation

## DRF Testing Results – Dummy Containment

- Open Window
  - Complete ejection in every case
- Inflatable Systems
  - Prevented complete ejections
  - Shoulders & arms escaped below bag
- Advanced Glazing (tri-laminate only)
  - Prevented complete and partial ejections
- Combination Systems
  - Prevented complete and partial ejections

# Ejection Mitigation Dummy Containment



DRF\_44\_Front



DRF\_66\_Front



DRF\_62\_Front



Drf\_85\_Front

# Ejection Mitigation

## DRF Testing Results – Dummy Responses

- Low Head Injury Potential
  - Maximum  $HIC_{36} = 121$
- Low Neck Tension
  - Maximum - 33% IARV (per FMVSS 208)
- Generally Low Neck Compression
  - Maximum - 82% IARV (per FMVSS 208)
  - All the rest below 60%
  - Higher values from contact with side roof rail while engaged with countermeasure

# Ejection Mitigation

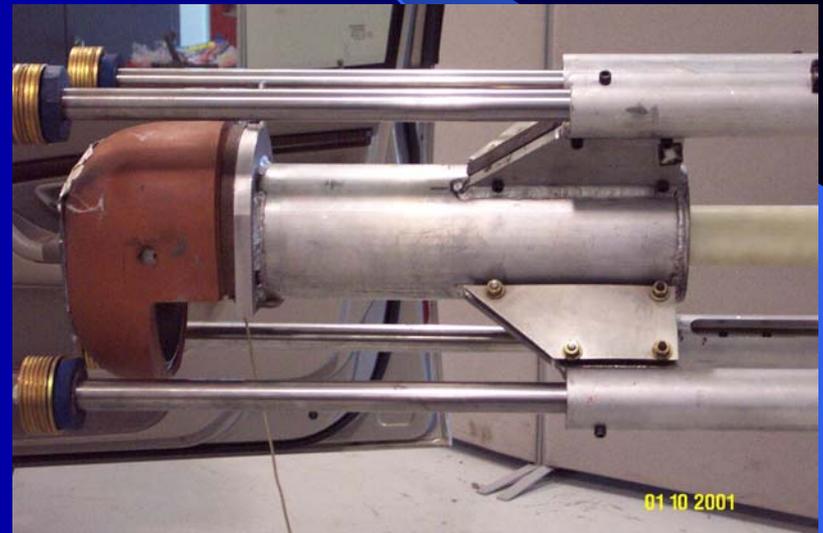
## DRF Testing Results – Dummy Responses

### Lateral Neck Loading

- Maximum Shear Loads
  - 50<sup>th</sup> male – 1020 N
  - 5<sup>th</sup> female – 754 N
- Maximum Bending Moments
  - 50<sup>th</sup> male – 61 N-m
  - 5<sup>th</sup> female – 42 N-m
- No Established Injury Criteria

# Ejection Mitigation Guided Impactor

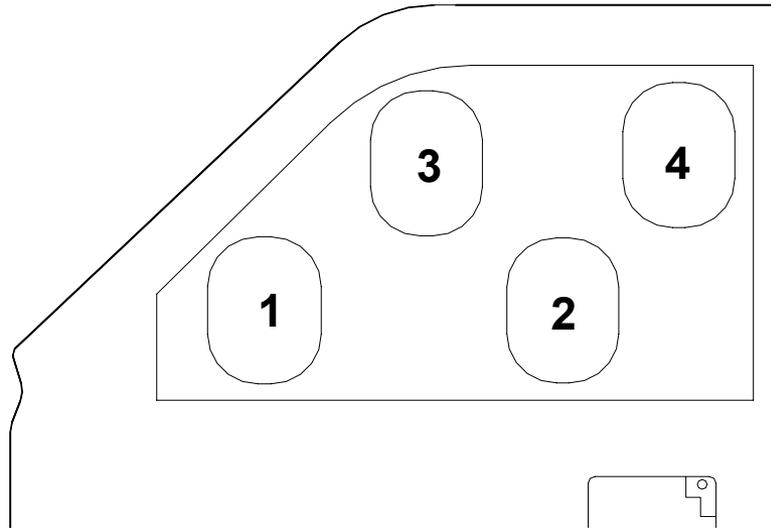
- 18 kg mass
- Featureless Headform
  - Average of front & side of head
- Measures Deflection
- Positioned Inside Vehicle
- Impact a Variety of Locations





# Ejection Mitigation

## Side Window Impact Locations



# Ejection Mitigation Production System



# Ejection Mitigation Guided Impactor Test Results

- Considerable Previous Testing of Advanced Glazing Systems
  - Containment up to 24 kmph
  - Excursions of 100 to 250 mm
- Very Limited Testing of Inflatable Systems
  - At some locations, containment up to 24 kmph
    - Little or no excursion
  - At other locations, no containment capability

# Ejection Mitigation Guided Impactor

- May Be Suitable For Evaluating Occupant Retention
- Potentially More Stringent Than DRF
  - More concentrated loading area
  - Stringency can be varied by:
    - Selection of impact locations
    - Impact speed
    - Excursion criterion

# Ejection Mitigation Ongoing Research

- DRF Testing of More Systems
  - Full-dummy retention
  - Injury causing potential
- Guided Impactor Testing
  - Most of the work still to be done
  - Evaluate systems
  - Establish test parameters, criterion
- Rollover Sensor Performance Test
  - Evaluate existing and/or develop new methods



**THE END**